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(54) Magnesium alloy

(57) An Mg-Al-RE alloy is disclosed wherein the amount of the rare earth component may be reduced while optimal tensile strength and durability are obtained. The alloy further includes a small calcium component. A high degree of creep resistance is obtained. Further copper and/or zinc may be introduced for providing favorable tensile characteristics. The compositional range is: 1.5 - 10% Al, less than 2% RE, 0.25 - 5.5% Ca, optionally 0.2 - 2.5% Cu and/or Zn, and balance Mg.

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AB32Y AB33X AB331 AB333 AB335 AB337 AB339  
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AB395 AB398 AB397 AB399 AB419 AB439 AB459  
AB46Y AB48X AB481 AB483 AB465 AB487 AB489  
AB519 AB539 AB549 AB559 AB610 AB613 AB614  
AB619 AB62X AB621 AB624 AB627 AB630 AB835  
AB66X AB661 AB663 AB665 AB667 AB669 AB670  
AB675 AB682 AB684 AB686 AB688 AB70X AB702

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(58) Field of Search  
UK CL (Edition N) C7A

3873

רכוש של מפעלי ים המלח בע"מ  
גס פרגה

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1990.

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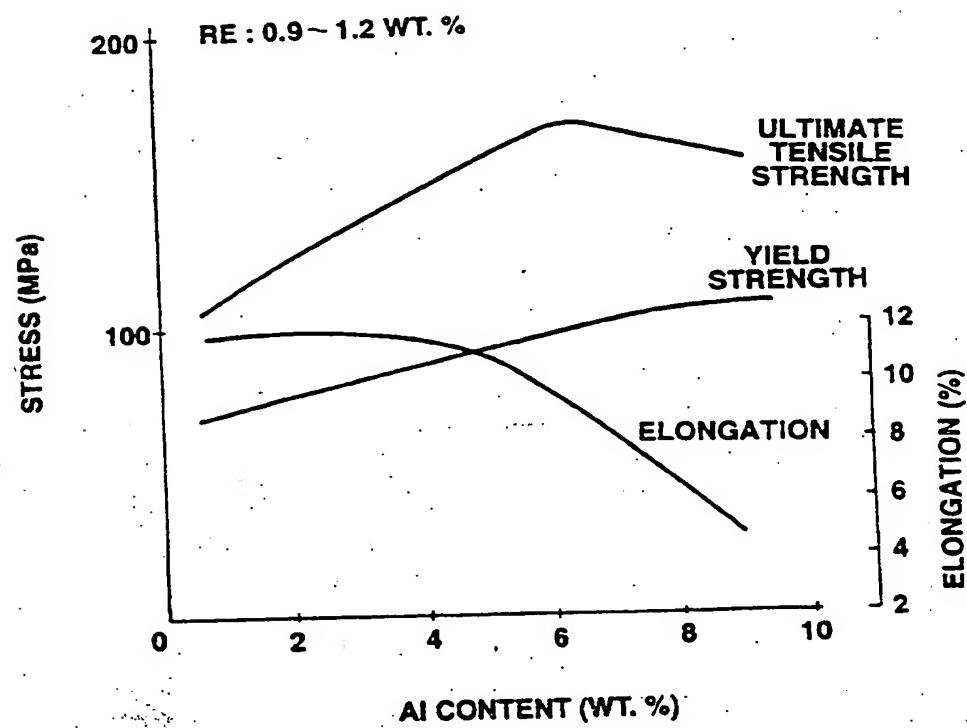
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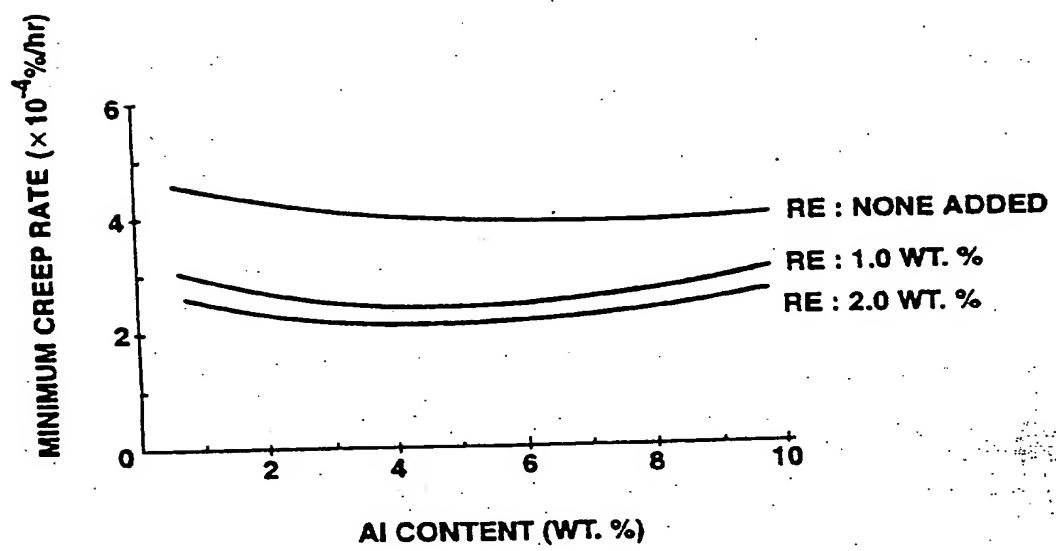
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FIG.1



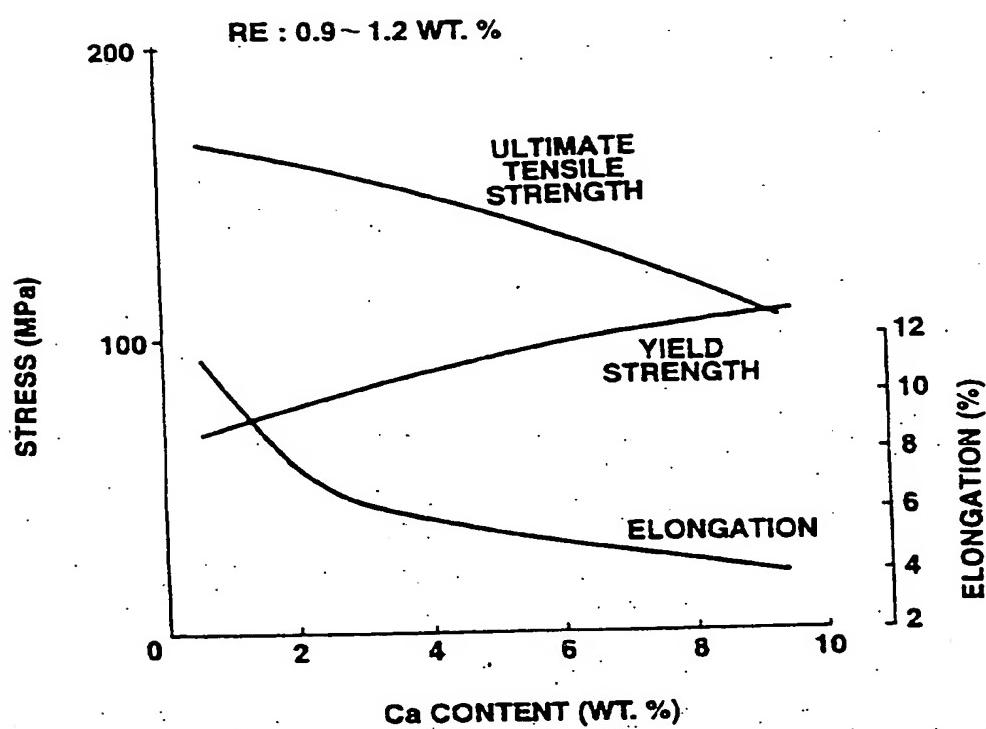
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**FIG.2**



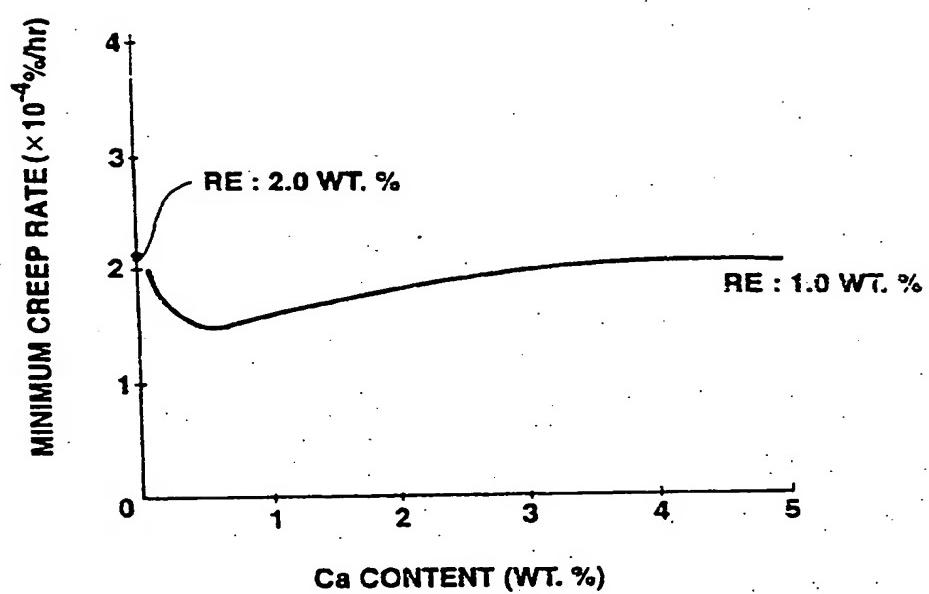
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**FIG.3**



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**FIG. 4**



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**MAGNESIUM ALLOY**

The present invention relates generally to a magnesium alloy for industrial use.

Metallic alloys utilizing magnesium are widely used for automotive, electronic, aerospace, and various industrial applications. Particularly, such alloys are favorable which have high-temperature creep strength and which may be utilized in high-temperature environments.

Various magnesium alloys have been developed and registered such as JIS H 5203 (MC1 - MC10) and JIS H 5303 (MDC1A; MDC1B) magnesium alloys. For high temperature environments, AE42 having Mg-4%Al-2%RE developed by Dow Chemical is well known.

Such a heat-resistant magnesium alloy is difficult to utilize in die casting where fast cooling is employed after molding of a metal article.

Further, a rare earth (RE) component included in such alloys increases costs and high temperature creep resistance is reduced.

It would therefore be desirable to be able to overcome the drawbacks of the prior art.

It is an object of the present invention to provide an Mg-Al-RE magnesium alloy wherein RE is reduced and a small Ca component is introduced, while retaining a high degree of creep resistance and favorable bending characteristics.

Accordingly, the present invention provides a magnesium containing metallic alloy

material comprising: an aluminium (Al) component contained in a range of 1.5 - 10% by weight; a rare earth (RE) component contained in a range of less than 2% by weight; a calcium (Ca) component contained in a range of 5 0.25 - 5.5% by weight; and wherein the remainder of the alloy is comprised of magnesium (Mg).

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 is a stress graph showing ultimate tensile strength, yield strength and elongation in relation to Al-RE content;

Fig. 2 is a graph illustrating minimum creep rate in relation to Al content for alloys having various levels of RE content;

Fig. 3 is a graph comparing stress and Ca content in relation to various characteristics in alloys containing RE in a given range; and

Fig. 4 is a graph showing minimum creep rate characteristics in Ca containing alloys in relation to a given amount of RE contained in the alloy.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the accompanying drawings, a preferred embodiment of the invention will be described hereinbelow in detail.

The present invention seeks to provide a Mg-Al-RE magnesium alloy wherein RE is reduced while a small Ca component is introduced, while retaining a high degree of creep resistance. According to the invention, additional Cu, Zn components may be introduced together or singly for providing favorable bending characteristics to the alloy material.

Various alloys have been formed according to generally known melting technique in a steel crucible having a nickel (Ni) component removed therefrom in an ambient atmosphere comprised of a gas such as SF<sub>6</sub>, CO<sub>2</sub> or

air.

Referring to Table 1, thirty-eight alloys have been utilized including nineteen embodiments of the alloy of the invention developed by the inventors through experimentation, and nineteen samples for comparision, including the above mentioned conventional alloy. The pieces were tested for various characteristics such as ultimate tensile strength, yield strength, elongation and minimum creep rate. Table 2 shows the effects of the various alloy compositions:

TABLE I

SAMPLE TYPE	AI	Mn	RE	Cs	Cu	Weight %	Zn	Ni	COMMENTS
COMPARISON 1	2.0	0.39	-	-	-	-	-	-	REMAINDER
COMPARISON 2	4.1	0.29	-	-	-	-	-	-	REMAINDER
COMPARISON 3	9.5	0.25	-	-	-	-	-	-	REMAINDER
COMPARISON 4	2.1	0.38	0.49	-	-	-	-	-	REMAINDER
COMPARISON 5	3.9	0.28	0.51	-	-	-	-	-	REMAINDER
COMPARISON 6	1.9	0.41	1.1	-	-	-	-	-	REMAINDER
COMPARISON 7	4.1	0.31	1.2	-	-	-	-	-	REMAINDER
COMPARISON 8	2.0	0.41	2.1	-	-	-	-	-	REMAINDER
EMBODIMENT 1	2.0	0.38	0.90	0.32	-	-	-	-	REMAINDER
EMBODIMENT 2	4.1	0.29	1.1	0.31	-	-	-	-	REMAINDER
EMBODIMENT 3	5.9	0.32	1.2	0.30	-	-	-	-	REMAINDER
EMBODIMENT 4	9.4	0.25	1.0	0.29	-	-	-	-	REMAINDER
EMBODIMENT 5	1.9	0.39	0.90	1.0	-	-	-	-	REMAINDER
EMBODIMENT 6	4.0	0.35	1.1	0.30	-	-	-	-	REMAINDER
EMBODIMENT 7	6.1	0.32	1.2	1.1	-	-	-	-	REMAINDER
EMBODIMENT 8	9.5	0.28	1.1	1.0	-	-	-	-	REMAINDER
EMBODIMENT 9	2.0	0.42	0.90	3.0	-	-	-	-	REMAINDER
EMBODIMENT 10	4.2	0.33	0.90	3.1	-	-	-	-	REMAINDER
EMBODIMENT 11	5.9	0.31	1.1	3.2	-	-	-	-	REMAINDER
EMBODIMENT 12	9.3	0.28	1.0	3.0	-	-	-	-	REMAINDER
COMPARISON 9	0.5	0.40	-	-	-	-	-	-	REMAINDER
COMPARISON 10	1.1	0.42	-	-	-	-	-	-	REMAINDER
COMPARISON 11	0.4	0.42	1.0	0.25	-	-	-	-	REMAINDER
COMPARISON 12	0.5	0.42	1.1	1.1	-	-	-	-	REMAINDER
COMPARISON 13	0.5	0.38	1.0	3.1	-	-	-	-	REMAINDER
COMPARISON 14	0.4	0.39	1.2	5.1	-	-	-	-	REMAINDER
EMBODIMENT 13	1.9	0.36	0.90	5.0	-	-	-	-	REMAINDER
EMBODIMENT 14	4.0	0.38	1.1	4.9	-	-	-	-	REMAINDER
EMBODIMENT 15	5.8	0.29	1.2	5.1	-	-	-	-	REMAINDER
EMBODIMENT 16	9.6	0.27	1.0	5.0	-	-	-	-	REMAINDER
COMPARISON 15	4.0	0.33	1.9	-	-	-	-	-	REMAINDER AE12 Alloy
COMPARISON 16	3.9	0.34	2.3	0.25	-	-	-	-	REMAINDER
COMPARISON 17	4.0	0.35	2.4	1.1	-	-	-	-	REMAINDER
COMPARISON 18	4.1	0.32	2.3	3.1	-	-	-	-	REMAINDER
COMPARISON 19	4.0	0.33	2.3	5.1	-	-	-	-	REMAINDER
EMBODIMENT 17	4.0	0.34	1.1	0.2	0.5	-	-	-	REMAINDER
EMBODIMENT 18	4.0	0.34	1.1	0.5	-	2.0	-	-	REMAINDER
EMBODIMENT 19	4.1	0.32	1.2	0.2	0.5	0.5	-	-	REMAINDER

TABLE 2

SAMPLE TYPE	BENDING STRENGTH (MPa)	DURABILITY (MPa)	STRETCH (%)	SMALLEST CREEP SPEED ( $10^{-4}\%/\text{hr.}$ )
COMPARISON 1	75	38	9.2	5.96
COMPARISON 2	90	56	12.3	5.85
COMPARISON 3	115	72	10.5	5.82
COMPARISON 4	123	58	8.5	4.76
COMPARISON 5	143	85	11.3	4.63
COMPARISON 6	121	81	12.0	4.42
COMPARISON 7	125	92	11.6	4.15
COMPARISON 8	110	80	8.5	2.3
EMBODIMENT 1	160	65	13.1	1.63
EMBODIMENT 2	169	110	12.3	1.55
EMBODIMENT 3	195	84	13.2	1.95
EMBODIMENT 4	168	108	15.0	2.36
EMBODIMENT 5	135	65	8.5	2.26
EMBODIMENT 6	171	68	9.9	1.62
EMBODIMENT 7	162	59	10.5	1.79
EMBODIMENT 8	123	48	11.2	1.89
EMBODIMENT 9	128	116	4.2	1.75
EMBODIMENT 10	159	81	5.9	1.89
EMBODIMENT 11	156	92	4.5	1.72
EMBODIMENT 12	150	110	2.9	1.94
COMPARISON 9	83	41	18.0	6.57
COMPARISON 10	92	47	17.2	6.42
COMPARISON 11	110	105	1.2	4.95
COMPARISON 12	113	107	1.1	4.83
COMPARISON 13	124	111	<1.0	4.80
COMPARISON 14	131	115	<1.0	4.72
EMBODIMENT 13	135	111	3.4	1.95
EMBODIMENT 14	146	91	5.2	2.03
EMBODIMENT 15	129	92	4.4	1.67
EMBODIMENT 16	160	112	3.0	1.94
COMPARISON 15	165	75	14.0	2.51
COMPARISON 16	167	79	13.7	2.49
COMPARISON 17	169	85	11.0	2.45
COMPARISON 18	171	86	7.5	2.32
COMPARISON 19	171	86	4.2	2.21
EMBODIMENT 17	190	76	11.9	2.19
EMBODIMENT 18	205	86	12.9	2.05
EMBODIMENT 19	195	78	11.4	2.13

2-0.9-0.3  
4-1-0.3  
5.9-1.2-0.3  
9.4-1.0-0.3  
1.9-0.9-1.0  
4-1.1-0.9  
6.1-1.2-1.1  
9.5-1.1-1.0  
2.0-0.9-3.0  
4.2-0.9-3.1  
5.9-1.1-3.2  
9.3-1.0-3.0

1.9-0.9-5.0  
4.0-1.1-6.9  
5.8-1.2-5.1  
5.6-1.0-5.0

AE 42

9.0+11+0.2+0.5 Cu  
9.0+1.1+0.5+2 Zn  
4.1-1.2+0.2+0.5 Zn+0.5 C

As may be seen from the Tables, embodiments 1 - 12 have favorable mechanical characteristics while RE is reduced compared with AE42 or the like, and high temperature creep strength is advantageously retained.  
5 Moreover, embodiments 13 - 15 include a Cu and/or Zn component, having ultimate tensile strength of about 200 MPa and yield strength of about 80 MPa. Also, a minimum creep rate of  $2.0 \times 10^{-4}\%/\text{hr}$  is obtained, while uniform temperature tensile characteristics are highly favorable.

10 It will be noted that high temperature creep strength is improved in comparison with AE42 and the other comparative examples, as shown in the tables.

15 While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the scope of the invention. Therefore, the invention should be understood to include all possible embodiments and modifications to  
20 the shown embodiments which can be embodied without departing from the scope of the invention as set forth in the appended claims.

Claims:-

1. A magnesium-containing metallic alloy material containing:  
an aluminium component, 1.5 to 10 wt.%;  
a rare earth component, less than 2 wt.%;  
a calcium component, 0.25 to 5.5 wt.%; and  
magnesium, the balance.
2. An alloy material as claimed in claim 1, containing a copper component and/or a zinc component in an amount of 0.2 to 2.5 wt.%.
3. A magnesium-containing metallic alloy material substantially as described with reference to any one of Embodiments 1 to 19.

**Patents Act 1977**  
**Examiner's report to the Comptroller under Section 17**  
**(The Search report)**

**Application number**  
**GB 9426064.3**

**Relevant Technical Fields**

- (i) UK CI (Ed.N) C7A  
(ii) Int CI (Ed.)

**Search Examiner**  
**R B LUCK**

**Databases (see below)**

(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

**Date of completion of Search**  
**10 MARCH 1995#**

(ii)

**Documents considered relevant following a search in respect of Claims :-**  
**1-3**

**Categories of documents**

X: Document indicating lack of novelty or of inventive step.

P: Document published on or after the declared priority date but before the filing date of the present application.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

A: Document indicating technological background and/or state of the art.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1427602 (VARTA BATTERIE AG)	1 & 2
X	GB 1196767 (DOW CHEMICAL CO)	1 & 2
X	GB 1163200 (NASH HYDRO-ELEKTRISK ETC)	1 & 2
X	GB 690785 (DOW CHEMICAL CO) see especially Example 10 in Table	1 & 2
X	EP 0419375 (PECHINEY)	1 & 2
X	EP 0414620 (PECHINEY)	1 & 2
X	WO 89/08154 (PECHINEY)	1 & 2
X	US 5073207 (PECHINEY)	1 & 2

**Databases:** The UK Patent Office database comprises a unified collection of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

